AD-784 033

FEASIBILITY STUDY OF X-RAY GAGING FOR ON LINE TESTING OF SHELL CASES FOR (SMALL CALIBER AMMUNITION MODERNIZATION PROGRAM) PROJECT

Anthony C. Piazza

Army Materiel Command

Prepared for:

Texas A and M University

March 1973

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
USAMC-ITC-2-73-17

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER
AD-784033

4. TITLE (and Subtitle)
FEASIBILITY STUDY OF X-RAY GAGING FOR ON LINE TESTING OF SHELL CASES FOR "SCAMP" PROJECT

5. TYPE OF REPORT & PERIOD COVERED
Final

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Anthony C. Piazza
DR. J. W. Foster

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Product/Production Graduate Engr Program
USAMC Intern Training Center
Red River Army Depot, Texarkana, TX 75501

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Product/Production Graduate Engr Program
& Texas A&M University Graduate Center
USAMC Intern Training Center - USALMC

12. REPORT DATE
March 1973

13. NUMBER OF PAGES
41

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)

15. SECURITY CLASS. (of this report)

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for Public Release: Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES
Research performed by Anthony C. Piazza and Dr. J. W. Foster, Industrial Engineering department, Texas A&M University.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Cartridges, Detection Systems, Acceptance Inspection, Quality Control, Testing

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this research is a feasibility study of X-ray gaging for on line testing of shell cases for project "SCAMP". The advantages and disadvantages of solid state X-ray gaging are qualitatively discussed and quantitatively weighed.

It is concluded that solid state X-ray gaging of production line products at high speed is now coming into its own with the use of minicomputers and shows great promise for use on the "SCAMP" project.

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ACKNOWLEDGMENTS

Gratitude is extended to Dr. J.W. Foster who closely observed the progress of this research and provided many invaluable suggestions. Support from Mr. R.G. Schonberg of Philips Electronic Instruments was also greatly appreciated.

During the course of this work, the author was employed by the U.S. Army as a career intern in the AMC Product/Production Design Engineering Graduate Program. The author is grateful to the U.S. Army for the opportunity to participate in this program.

CONTENTS

FIGURES

CHAPTER I

INTRODUCTION

The term "nondestructive testing" is a general name given to all test methods which permit testing or inspection of material without impairing its future usefulness. From an industrial viewpoint, the purpose of nondestructive testing is to determine whether a material or part will satisfactorily perform its intended function.

It must be realized that the desired properties or qualities must be built into a product; they cannot be inspected into it. The primary purpose of a nondestructive inspection is to determine the existing state or quality of a material, with a view to acceptance or rejection. By use of nondestructive testing methods and techniques it has been possible to decrease the factor of ignorance about material without decreasing the factor of safety in the finished product. Absolute, perfect, and sound industrial material does not exist. Any correctly applied nondestructive test can tell only whether the relative soundness of a specimen lies within specified tolerances. The use of nondestructive testing has been and is being more fully recognized by management as a means of meeting consumer demands for better products, reduced cost, and increased production.

In radiography X-ray and Gamma radiation the so-called "penetrating radiation" is used. Variation in thickness and density modify the passage of radiation through the test specimen. This variation in the

intensity of the transmitted radiation can be detected in a variety of ways, by use of film, semiconductors, photoconductors, and scintillation crystals.

Since the discovery of X-rays, radiographic examinations and tests have been used primarily for medical and industrial applications. One industrial application is the inspection of castings and welds. Until a few years ago, X-ray technology advanced very slowly, especially as related to quality control; however, when the space age came into being, the need arose for new inspection techniques, and the use of radiographic inspection spread to this new field. Gradually, this inspection technique moved into the area of electronics. Resistors, capacitors, diodes, and transistors were being radiographed with startling results, and this encouraged even wider use of radiographic inspection, especially in critical space applications.

During the last century, the development of small arms has undergone a very drastic change, from muzzle loaders to fully automatic rifles and machine guns. In recent years small arms for field troops have gone from fire power of a 100 to 200 rounds per minute to over 600 rounds per minute, but the production of ammunition has not advanced to the same degree. Therefore, the United States Army Materiel Command has implemented a program for the modernization of small caliber ammunition production facilities (SCAMP).

SCAMP provides for the acquisition, installation, and tryout of a new generation of production equipment rather than the replacement of existing manufacturing equipment which was designed over some thirty to fifty years ago. The new generation of production equipment is capable of production rates of 1200 rounds per minute, and at this rate non-

destructive quality control has become a very serious block in the production line.

This report is concerned with the feasibility study of an automated X-ray inspection unit. Chapter II is a literature survey of X-ray gaging crystals and the use of these crystals in automated systems. In Chapter III and IV the proposed system and conclusions will be discussed respectively.

CHAPTER II

REVIEW OF THE LITERATURE

X-ray Units

X-ray generators may be classified as self-rectified or as rectified X-ray machines. The usual practice in industrial radiographic apparatus is to connect the high voltage transformer directly to the X-ray tube, as shown in Figure 1. This arrangement is known as the self-rectified circuit because the high voltage alternating current is rectified in the X-ray tube. This type of rectified system is used in portable X-ray equipment.

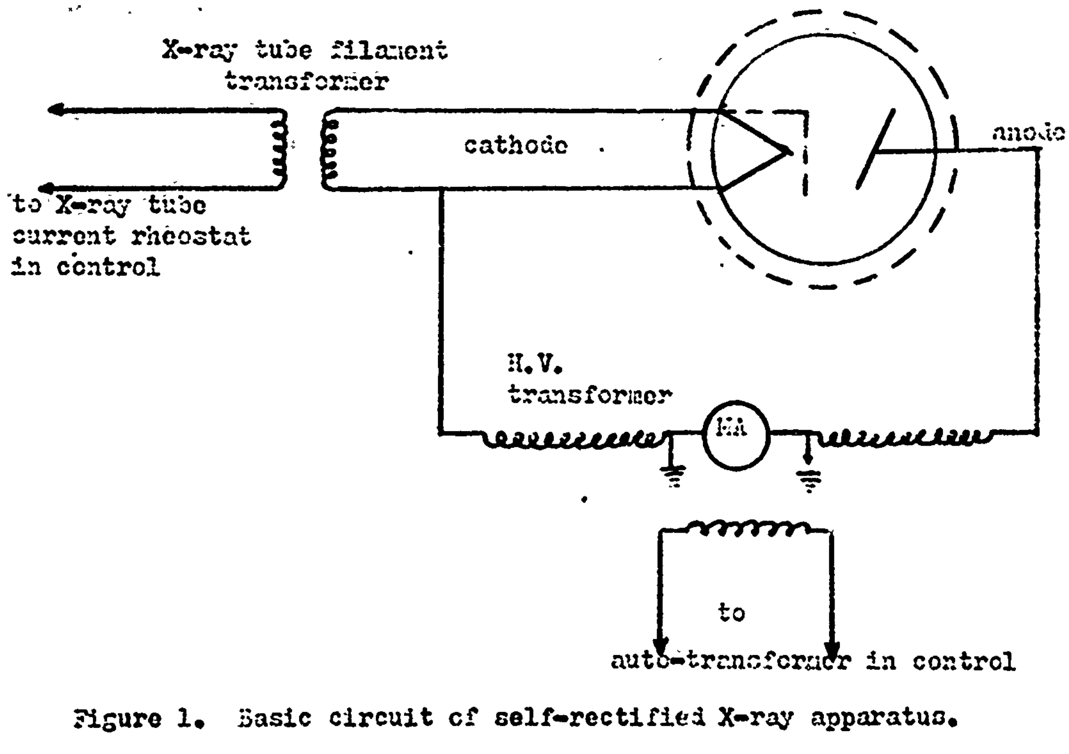

Figure 1. Basic circuit of self-rectified X-ray apparatus.

A rectifier to change the alternating current from the high voltage transformer to direct current is sometimes used with the net effect of increasing the X-ray machine output. This gain is achieved because loading of the focal spot is more uniform, inverse electron emission from the target is prevented, effects of charge reversal on tube walls are eliminated, and dielectric heating of transformer insulation is reduced. Rectification is at present usually obtained through the use of rectifier valve tubes. Four rectifier tubes are used in the bridge circuit for full-wave rectification, shown in Figure 2.

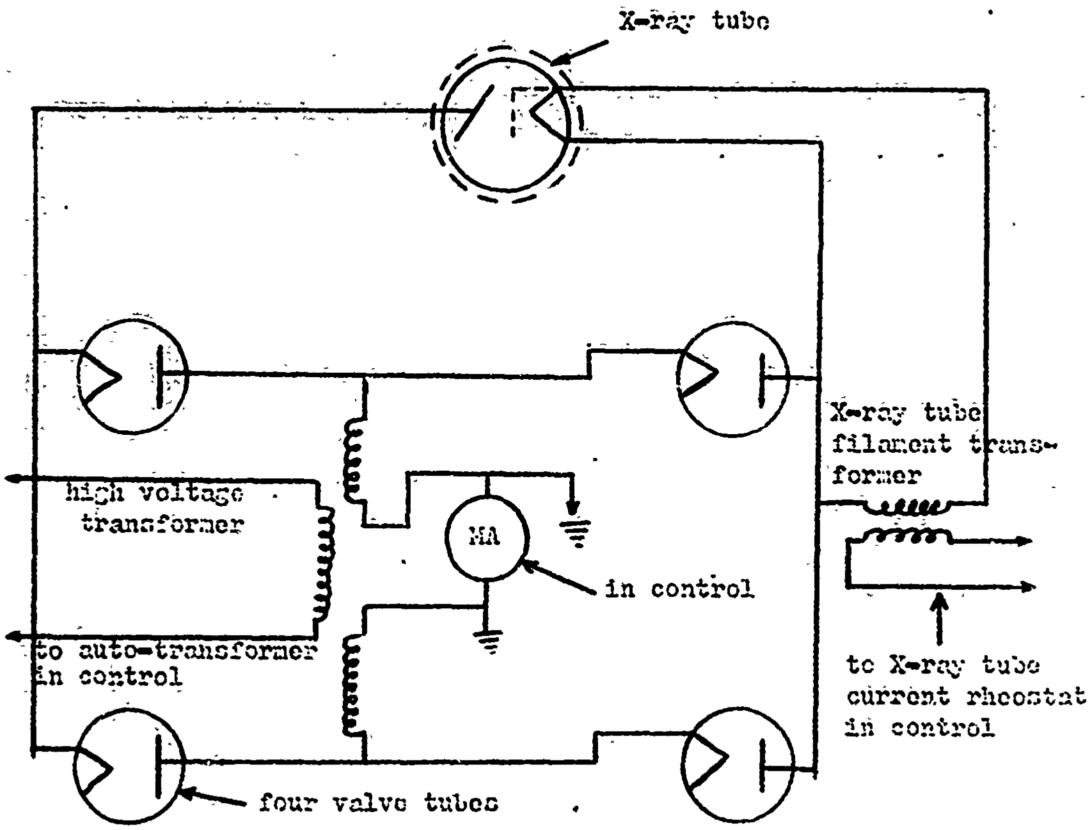

Figure 2. Basic circuit of rectified X-ray apparatus

The X-ray generator control equipment enables the operator to obtain

the intensity, quantity, and duration of X-ray exposure desired and to coordinate it with other associated apparatus. This purpose is accomplished by altering and controlling the voltage and/or frequency of the current supply to the high voltage and filament transformers.

X-ray equipment is provided in a wide variety of designs and ratings to meet the diverse requirements of non-destructive testing. The factors affecting the selection of the apparatus most suitable for a particular area of application as stated in the "Nondestructive Testing Handbook" by Robert C. McMaster (9) * are:

1. The density and thickness of material to be radiographed or fluoroscoped.
2. The speed with which inspection is to be done and the number of radiographs needed per unit of time.
3. The configuration of material to be inspected.
4. The location of work, i.e., whether work can be brought to the machine or whether the work must be radiographed on the spot.

Solid-State Radiation Detectors

The efficiency of X-ray detectors is determined by two factors: 1. The absorption of the incident radiation; and 2. The conversion of the absorbed energy into photoelectrons and the resulting production of optical or electrical signals. In detectors for longer wavelength, i.e. visible or ultraviolet radiation, absorption offers no specific problems. However, the penetrating power of X-rays is so great that considerable thicknesses of matter are necessary to obtain an appreciable amount of

*The numbers in parentheses refer to numbers references in the list of References.

absorption.

Photoconductors which show high dark resistance and very high amplification of the primary photocurrents are hexogonal cadmium sulfide, cadmium selenide, and mercuris sulfide. Crystals of these materials can be synthesized. With such crystals a ratio of 1 : 10^4 between the dark current and the current under irradiation can be obtained with moderate X-ray intensities (9).

Accurate, simple, inexpensive X- and gamma -ray detection can be accomplished with photoconductive cells. Such substances as cadmium sulfide exhibit conductivity changes from about 10^{-11} ohm $^{-1}$ cm $^{-1}$ dark to 2×10^{-5} ohm $^{-1}$ cm $^{-1}$ in a 100 - r/hr 100 - kev X-ray beam. With such a dynamic resistance change no amplification is required. Only a battery, a conventional meter, and a CdS cell are necessary for a complete unit. The X- and gamma -ray spectral response extends from below 30 kev to above 2 mev. Intensities from 1 to millions of r/hr can be measured conveniently.

Reliability, low-impedance circuitry, small size, low power consumption, and extreme ruggedness make this type of detection highly desirable for portable gamma survey equipment, high-intensity industrial controls, remote area monitoring and intercavity medical applications.

The phenomenon of photoconductivity occurs in the variable energy region between the filled band and the conduction band. Electrons in the conduction band are free carriers. In motion they constitute a current flow when a potential difference is applied. Electrons in the upper levels are repeatedly being energized by thermal agitation into the conduction band and then trapped again. The intermediate energy bands between the conduction band and the filled band are absent in

perfect crystal and are created in real crystals by imperfections and activating impurities in the crystal lattice. The average energy of these states is determined by Fermi statistics and termed the Fermi level. See Figure 3.

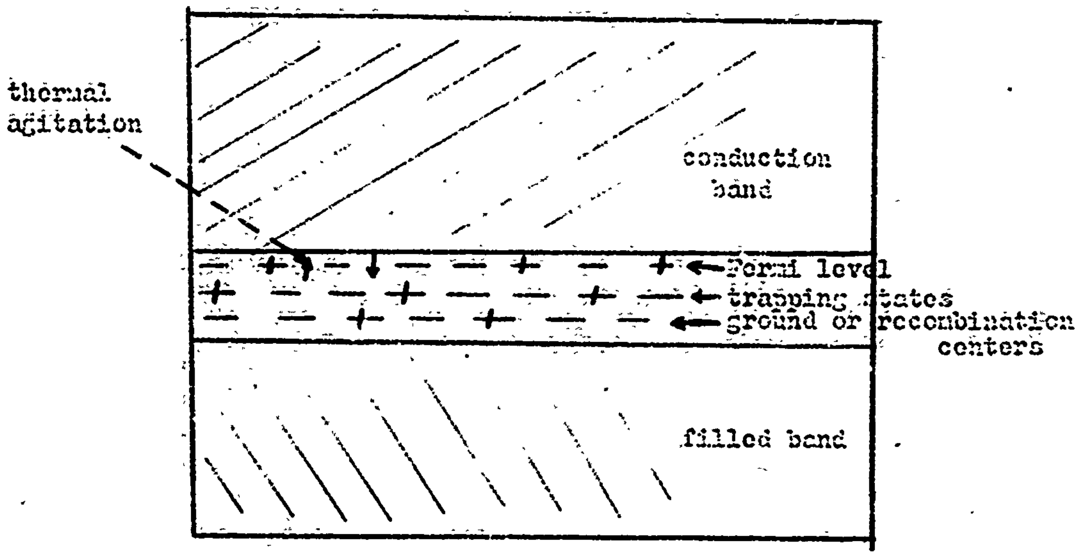

Figure 3. Photoconductivity - How it works.

Upon absorption of a gamma photon, a shower of electrons from the deeper levels are energized into the conduction band and become free carriers. The lifetime of these free carriers is determined by the recombination rate. The dark Fermi is determined by the steady state thermal equilibrium of the molecule. Upon irradiation, the energized electrons are at first rapidly retrapped but as the trapping levels "fill", raising the Fermi level, more free carriers are available to raise the conductivity of the substance. (3)

Among the properties of X-rays listed earlier is their ability to cause certain materials to fluoresce. This property is utilized in fluoroscopy in which the X-ray energy is converted to visible light. The advantages of fluoroscopy are that it is fast and economical. Unfortun-

ately, fluoroscopy has inherent limitations which have hitherto confined its application to a fairly narrow field.

In recent years, considerable attention has been focused upon the need for brighter fluoroscopic screens. It has been pointed out that the clarity of fluoroscopic vision should be improved many times and that if possible the need for dark adaptation before fluoroscopy should be eliminated. A few years ago work was begun in at least three laboratories in the United States to develop devices by which fluoroscopic screens may be brightened or intensified. Coltman at the Westinghouse Laboratories undertook investigations which culminated in the development of an electronic image tube capable of intensifying the fluoroscopic screen approximately 150 times. Comparatively little in the way of gain (about 100 times) over a conventional fluoroscopic screen is needed in order to reach the quantum limitation in the information content of the X-ray signal. The direct image converter tube developed by Coltman employs a several-stage process to convert the X-ray signal into a bright visual signal. (8)

A group in Eindhoven, Holland, has developed the Philips Image Intensifier. The Philips Image Intensifier and the Westinghouse units are commercially available. But the most recent development is that of the Marshall Space Flight Center which is called the Improved Radiographic Image Amplifier Panel.

The NASA Image Amplifier Panel is a layered image amplifier for radiographic (X-ray and gamma ray) applications offers a number of advantages over conventional layered devices used for radiographic image amplification. The new device is of relatively simple construction and provides images of higher contrast and better resolution over longer

storage periods than are attainable with previous image amplifiers of this type. The device also combines very high radiation sensitivity (10 milliroentgens, or less, of penetrating radiation required for optimum display, compared to 350 milliroentgens for a "Thorne" image amplifier) with fast image buildup and erasure capabilities. These characteristics are achieved by adding a layer of material that is both photoconductive and light-emitting to a basic image amplifier and cascading this assembly with a modified "Thorne" panel. When excited by X-ray or gamma ray radiation directed through a test specimen or anatomical region, the image amplifier produces a daylight-visual image of the radiographic structural details in its field of view.

The complete image amplifier panel consists of a number of layers, as seen in Figure 4.

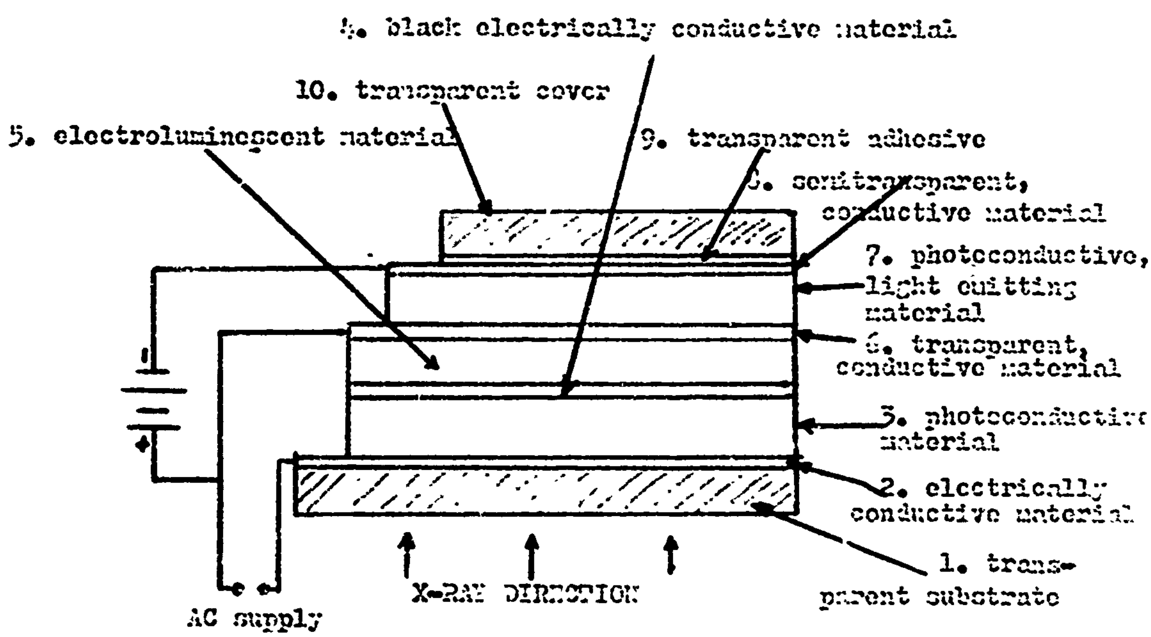

Figure 4. Improved Radiographic Image Amplifier Panel

In this design, layers 1 through 5 constitute an image amplifier of conventional design; layers 6 through 10 are a modified "Thorne" panel,

which is a second image amplifier in cascade with the basic first-stage image amplifier. Contacts to the electrical power supply are made at layers 3, 6, and 8. The total weight of a typical (10 inch X 10 inch) panel including battery power supply, is less than 10 pounds.

The panel is exposed similarly to X-ray film, but requires much less radiation and shorter time to develop than the film. The image on the stored panel remains visible for long periods after X-ray excitation is cut off. This image can be photographed and erased when desired in a fraction of a second leaving the panel ready for reuse. The imaging and erasure cycles can be repeated many thousands of times. This device should find advantageous application in industrial and medical radiography.

X-Ray Television System

Means are now available by which radiographic techiniques can be at least semiautomated, a large quantity of radiographic film can be eliminated. This equipment an X-ray Television System, utilizes a conventional X-ray generator in conjunction with an X-ray sensitive vidicon tube to produce a picture on a television screen. The closed-circuit television system is entirely electronic and does not employ energy transformations, such as an image intensifier. The X-ray beam is converted to electrical impulses in the vidicon tube and transmitted through cables to a conventional television monitor where the object under inspection can be directly viewed, normally with ten to thirty times magnification. Handling equipment may be used in conjunction with the system to achieve motion in the X and Y axes; rotational motion can also be achieved. When automatic loading devices are used, the operation of the system is highly automated.

Present Industrial Uses

Canned and packaged products can now be inspected for height of fill at instantaneous rates up to 1200 cans per minute. A tiny beam of X-ray passing through the containers, as they travel along on a convegor belt, falls upon a cadmium sulphide crystal X-ray detector. The crystal with its associated circuits measures the X-ray transmission of the containers to determine if the height of fill is above or below the pre-selected level. The containers filled above the selected level are passed and the ones below are removed from the conveyor belt. The inspection unit has a definition of better than 1/16" and contains a self monitoring circuit that makes it virtually unaffected by normal line voltage variations. (5)

Methods or systems for control of operations such as canned and packaged products have been used in industry for over 20 years. But no real sophistication has been developed until the late 1960's when certain developments from the aero space industry were incorporated into X-ray system.

In 1971 when the Philips Research Laboratory in Hamburg, Germany, needed a fast, reliable process to identify defective balls of fissionable material embedded in carbon and having a carbon shell (675,000 are used as fuel elements in a 300 mw neclear reactor), engineers solved the problem with the X-ray diagnostic system shown in figure 5. It can automatically check and sort 360 balls per hour with a high degree of accuracy. In a hypothetical test of 1 million defective balls, only one was erroneously passed as being good.

Each carbon ball, 6 cm (2.36 inches) in diameter, contains about 10,000 particles of fissionable material (uranium/thorium). The particles are about 0.35 cm (0.014 inches) in diameter. The balls have

5mm (0.20 inches) thick shells of pure carbon, which must be absolutely free of particles of fissionable material to ensure safe operation of the reactor. The testing device takes less than 10 seconds to determine whether a fuel element is free from faults.

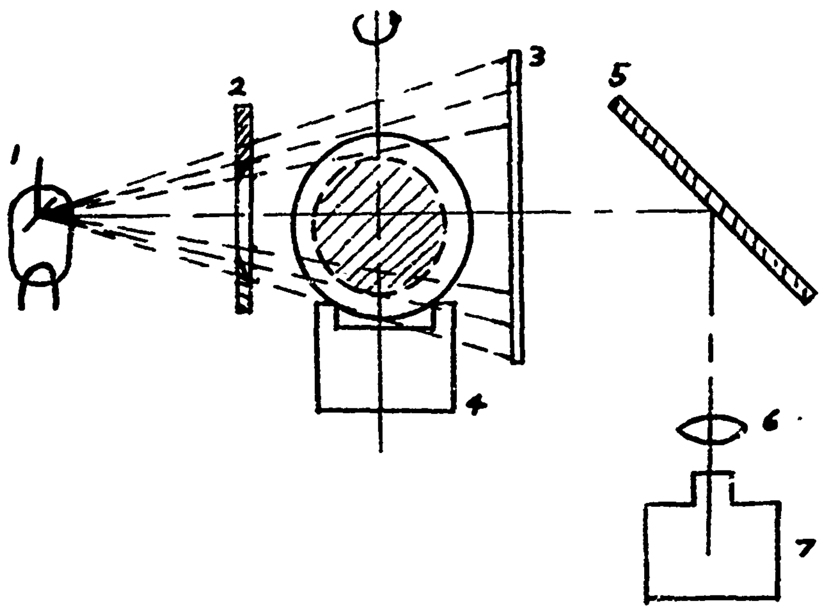

Figure 5 - The installation for rapid fluoroscopy of uranium balls includes 1. an X-ray tube, 2. an aluminum compensation ring, 3. a mechanism for rotating the ball, 4. a fluorescent screen, 5. a mirror for reflecting the X-ray image, 6. a lens, and 7. a television camera. The ball can also be tilted so that the entire area can be scanned by the television camera.

As shown in figure 5, a point X-ray source projects an image of the ball on a fluorescent screen. This image, reflected by a mirror, is scanned by a television camera. As the ball is rotated by an electric motor at 30 rpm, one rotation about its vertical axis allows a 90° zone to be scanned. Then the ball is tilted 45° about a horizontal axis so that the rest of the surface can be examined.

The low signal to noise ratio of the video signals produced by the television camera was the fundamental difficulty in this testing process. (It should be noted, of course, that a particle of fissionable material embedded in the carbon shell is difficult to detect against the background of the material in the ball because the contrast is very poor.)

To improve the signal to noise ratio, engineers placed an aluminum ring of appropriate profile between the X-ray source and the ball to compensate for the strong radical change in absorption in the shell, and added filter and correlation circuits as well.

As completed, the test installation fails to indicate only 1 out of 1 million defective balls. Furthermore, only one in 10,000 good ones are erroneously indicated as defective, which is negligible from the economic point of view. The purpose of the installation is, after all, to prevent defective balls getting into the reactor, and this is largely guaranteed by the installation's high ratio of accuracy, 1 : 1,000,000. (15)

Philips Electronic Instruments is at present one of the leading companies in automated X-ray inspection units in the United States and Europe. In the United States they developed an inspection unit for filled glass containers and for large industrial fuses. The basic unit employs a high quality, constant potential X-ray unit, a fine grain, high sensitivity fluoroscopic screen, and a high resolution closed circuit television chain coupled directly to a video memory disc.

Protection

One of the most important considerations in the X-ray or gamma ray laboratory is the provision and exercise of adequate safeguards for the personnel. The Safety Code for the industrial use of X-ray proposed by the American Standards Association should be complied with for new

installations, and existing installations should be checked to make certain that they meet the requirements.

Any of the body tissues may be injured by overexposure to X-rays or gamma rays, the blood, skin, and some internal organs being particularly sensitive. For this reason, persons who are exposed regularly to small quantities of X-rays or gamma rays should have periodic blood counts and physical examinations, under the direction of a physician, to note at the earliest possible moment any effects which might be attributed to these exposures.

Unless exposure to X-rays or gamma rays is kept at a minimum, the cumulative effect may cause injury to the body; therefore, it is essential that workers in the X-ray department be adequately protected against radiation at all times. Furthermore, protective measures should be so arranged that those in departments near the places where X-rays or radium are used are also safe. Precautions should be particularly observed when radiography must be done in the shop rather than in a specially protected radiographic department.

The voltages used to energize radiographic tubes are highly dangerous, and the best assurance of safety against hazard from them is the enclosure of high voltage parts in a shockproof container. Most X-ray generators for industrial radiography are of shockproof construction, but, where the design is such that high voltage conductors are exposed, operators should keep at a liberal distance from them and should guard against the possibility of sparkover to other conductors with which any person may be in contact. The most dangerous situation is to permit the body to form a part of the high voltage circuit, either across the tube leads or terminals, or between a high potential lead and a low potential

lead or a grounded conductor. (10)

CHAPTER III

AUTOMATED X-RAY INSPECTION UNIT

There are several methods of automating inspection of materials with X-rays. The simpliest type devices use photodiode sensors in conjunction with a fluoroscopic image. These have inherent limitations on accuracy, quantity of information and flexibility for multiple inspection use. Another method uses a closed circuit television viewed system with a flying spot scanning technique of the television screen. The information gained is of low sensitivity and the amount of information is very limited.

The inspection method proposed for shell case inspection utilizes the most modern techniques of image storage and comparision. The basic unit employs a high quality, constant potential X-ray unit, NASA's improved radiographic image amplifier panel, and a high resolution closed circuit television chain coupled directly to a video memory disc. Figures 6 and 7 show automated X-ray inspection units.

The disc can store up to 32 channels of information, 16 permanent storage channels and 16 temporary channels. Each permanent channel stores a standard unit of scan which matches a perfect inspection scan. When an inspection scan is placed on the disc, a comparison of the standard with the inspection scan is carried out by means of subtraction. Any information appearing at the output indicates a difference. The difference can then be sent to a gating element to determine whether the

magnitude is sufficiently large to actuate the rejection mechanism. Figure 8 shows an example of signal.

The shell cases must be oriented in a uniform manner such that a comparison of information with the standard does not have random position information superimposed.

X-Ray Units

A standard MG 150 Beryllium window with 20 ma beam capability and constant potential produced by Philip Electronic Instruments is proposed for use.

The X-ray unit using a water to air heat exchanger is self contained except for electrical power. This tube is designed with minimum inherent filtration, and is particulary suitable for radiographic and fluoroscopic examination of low density materials, as well as routine radiography in thick sections of dense materials. Typical applications are examination of alloys, plastics, rubber compounds, and the irradiation of biological specimens.

Shield Room

A lead-stell laminated housing large enough to contain the X-ray tube head, image amplifier panel, television camera and conveying system should be provided. The shield room shall meet all radiation hazard codes.

Access shall be by two doors, one on the end and the second on the side. Two reentrant mazes are used to assure safe movement of the shell cases into and out of the inspection region.

Interlocks on the doors and a warning light are used to assure safe operation and hazard warning.

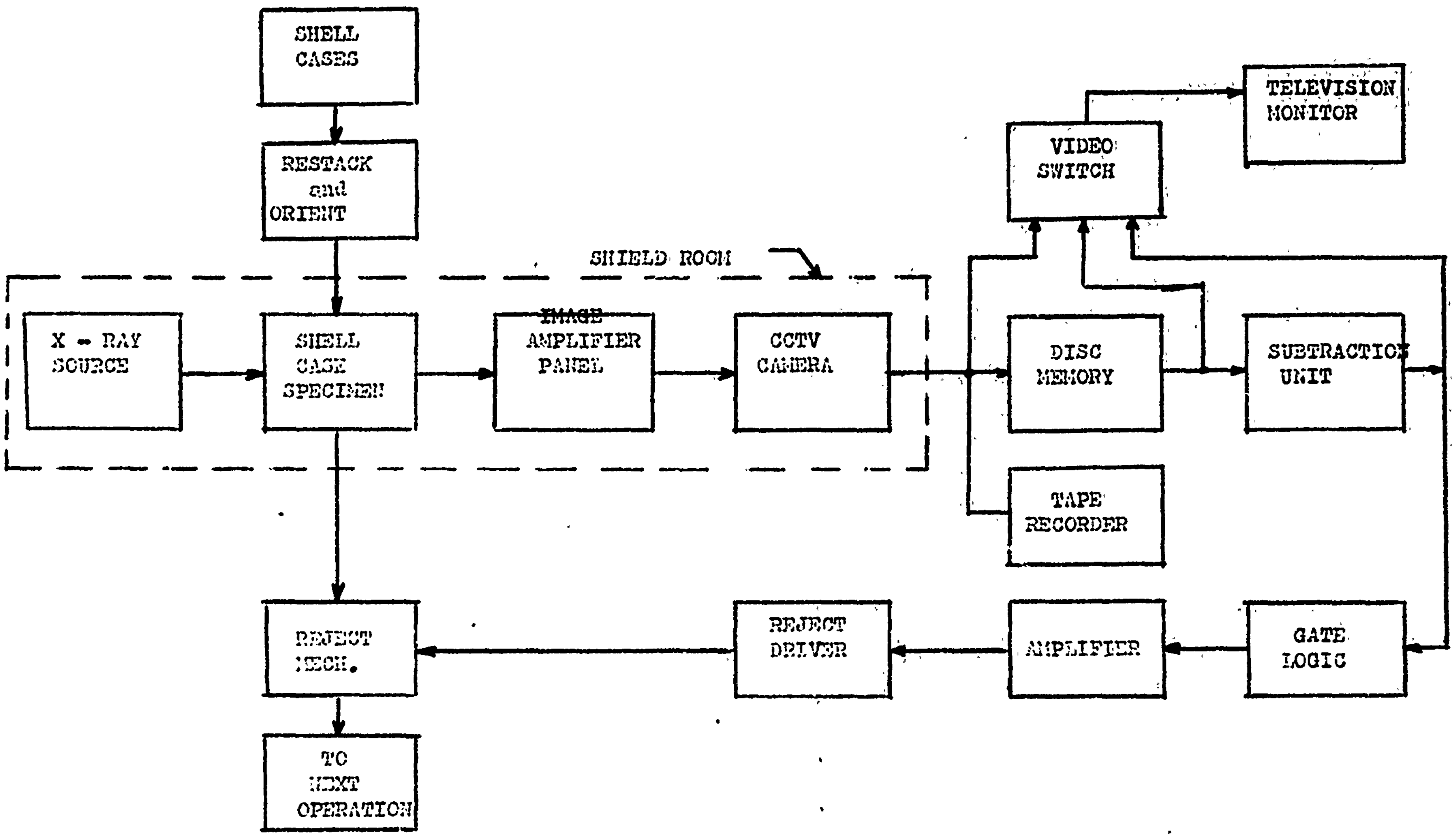

Figure 6. Proposed shell case inspection system block diagram.

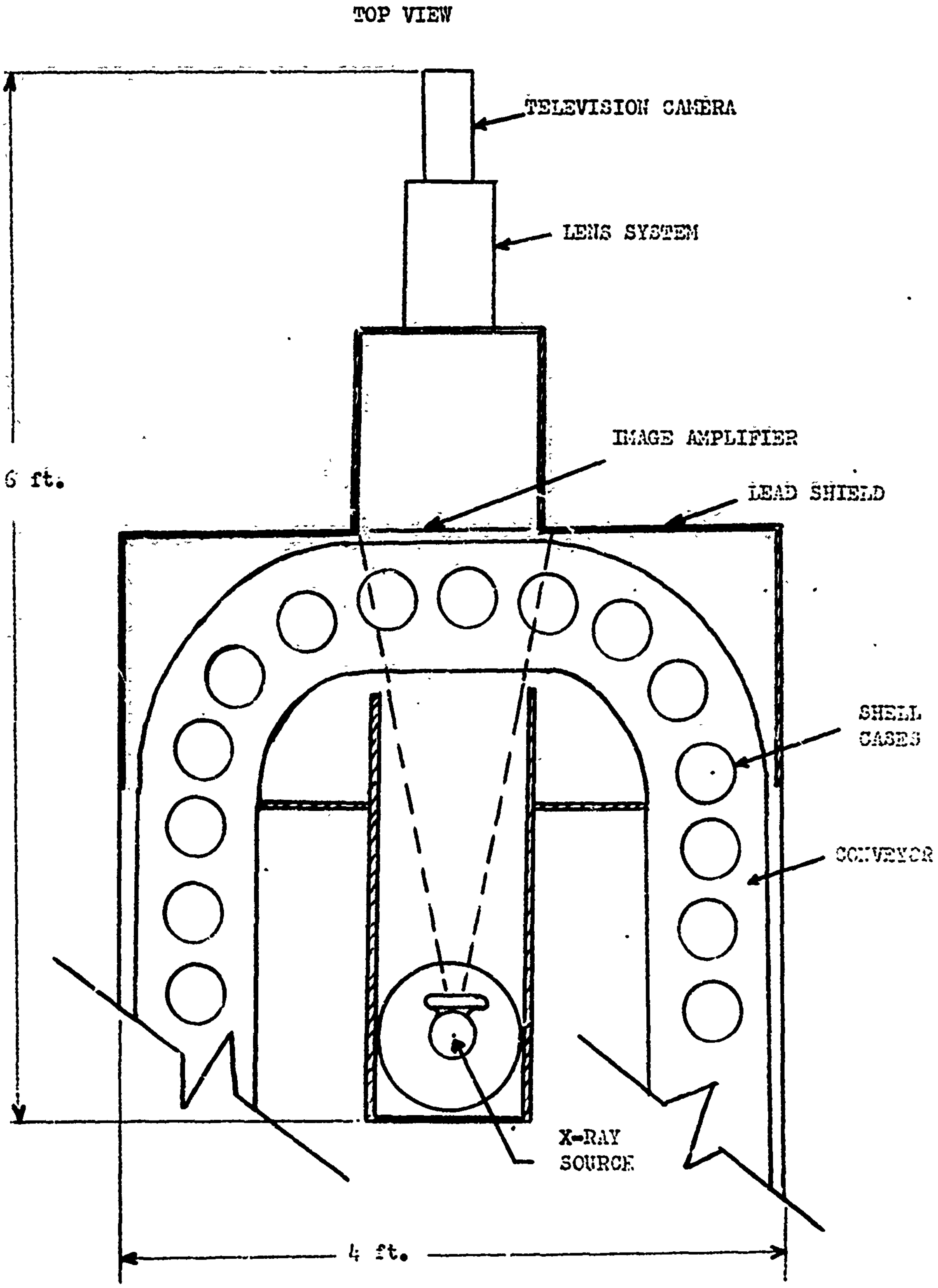

Figure 7. Automated X-ray Inspection System

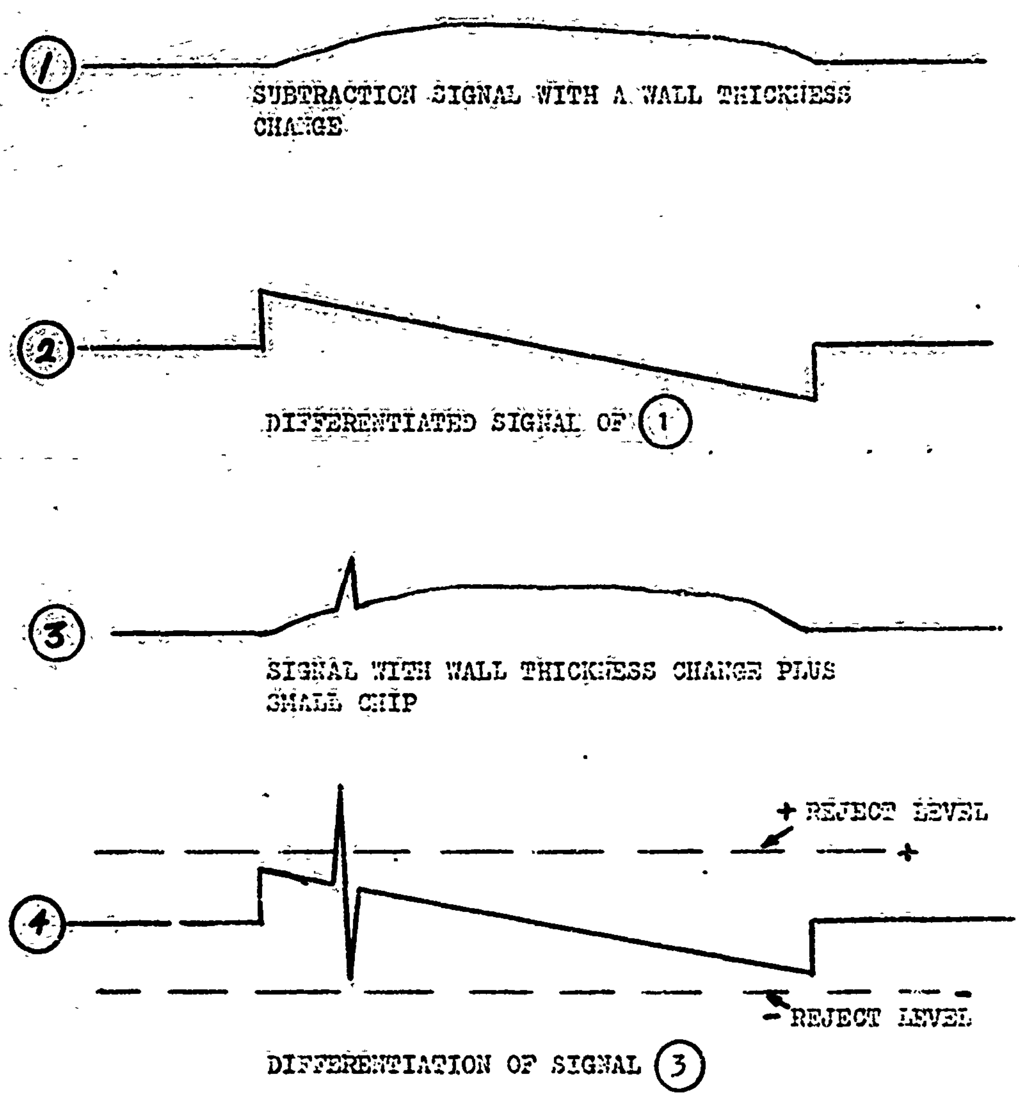

Figure 8. Example of signal processing using logic

Closed Circuit Television

A NASA improved image amplifier panel with a 10 inch by 10 inch viewing area is proposed. The closed circuit television employs a high quality vidicon tube with suitable wide angle lens to enable viewing a large area with minimum distance requirement between the screen and the camera.

The television system uses a 1029 line, 30 MHZ camera and control into a high resolution monitor. The resultant image complete through the image amplifier panel and television chain can resolve better than a 50 mesh over the central 3/4 of the image.

The video image presented on the television monitor may be selected from the camera output, memory disc storage, or subtraction processor for versatility in manual inspection and system monitoring. The complete inspection image is also fed onto a video tape for permanent record.

Information Processing

The subtraction unit produces a difference signal resulting from the differential signal between a standard and the inspection signal. The subtraction output is directed to a gate circuit with counting logic and amplitude selection. When a part is out of place, a signal appears. The amplitude of signal is measured and a pulse is generated when a preset level is exceeded. Each of the scan lines produces a count if a part is out of position. An integrator is used to determine the size error and the number of counts can be set to reject at a level well above noise. The time an error signal occurs is measured to produce information for location of the specimen producing the error. After processing the information and locating a faulty shell case, the reject mechanism is actuated to remove the proper shell case from the flow of material.

Recording and Display

The output from the television camera is coupled to a video tape recorder. Both the complete image and the subtraction image can be placed on tape. The television image presented on a monitor may also be switched to view either picture.

The record period for one frame of information is 1/30 second and at this rate of inspection the minimum inspection rate of 1200 shell cases per minute can easily be met. In manual mode of operation the monitor views the repeating single frame image stored on the disc.

Handling System

In order to achieve automated inspection using the system as described, it is necessary to orient the shell cases in a manner that assures a repeating exact pattern from a correctly set shell case with all parts in place.

Philips Electronic Instruments produces two handling systems, that with a little modification can be employed for use with the shell cases. The M219 and M551 both have a simple means of obtaining suitable orientation. The M219 has an offset hole in one end and the M551 has an indent on the outside which is oriented in a repeatable manner with respect to the groove in the plates. The shell cases arrive at the inspection unit either by conveyor chain or by buffer storage. The shell cases are then placed on inspection trays in indexed locations. The maximum usable inspection field is 8 inches by 8 inches. Each shell case has a particular orientation problem. The means of moving parts is proposed to be by vacuum pick up.

After placement in the inspection trays, the loaded tray will pass into the shielded X-ray enclosure by means of a reentrant opening.

The shell cases on the inspection tray are transported on a roll conveyor in continuous feed. At the point of inspection, the tray must stop for 1/30 second and then move on. An alternate storage track is employed, using an added channel of the memory disc for obtaining the new inspection information while the earlier tray information is being processed.

When the shell cases exit the X-ray housing, the faulty shell cases are removed, again by means of vacuum pick up. The remaining shell cases are sent on to the next operation.

A manual-automatic switch is provided to switch operating mode. In manual position, a stop-reverse-forward switch with variable speed is provided to inspect without automatic control. The reject mechanism is also switched off, so that manual removal of faulty shell cases is required.

General Requirements

The entire inspection station and local visual monitoring will fit within a room of size 7 feet by 8 feet by 15 feet. Electrical power required is 6 KW and no water, air or other utilities are required. All X-ray protection codes applicable shall be met with the equipment.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

The X-ray Television System eliminates most of the disadvantages of conventional radiographic inspection systems. Disregarding the initial, relatively high investment, (for the automated X-ray unit described in Chapter III) the cost is approximately $100,000 with transport mechanism included. The cost of performing radiographic examinations is significantly reduced because it takes less time, fewer materials, and less manpower to perform the examination. An additional advantage is that inspection can be performed on a real time basis, thereby expediting decision making and reducing the paperwork involved. A third major advantage is that the system is dynamic, that is, the parts undergoing inspection can be observed while they are in motion (in rotation, translation, or possibly vibration.) Not only does the X-ray Television System have economic advantages, but with the capability of motion and real time radiography, a broad new field has also been opened to the quality and reliability engineer. When using conventional radiographic techniques, a separate film is made for each position of a specimen if a record is needed. With the X-ray Television System, the part can be viewed in a sequence of positions and the best position for photographing selected if a record is required. If no record of inspection is required, the system can be used on a go-no-go basis.

The Appendix of this report shows some of the defects that can result in the manufacturing of shell cases. The defective shell case pictures are from MIL-STD-636, and are at present the guide line for the visual inspection method.

In comparision to the Laser System which has been in the research stage for several years now the Automated X-ray Unit has many advantages. With the Laser System, the positioning and cleanliness of the shell cases is much more critical. The biggest disadvantage of the Laser System is that it is only capable of detecting surface defects but if a defect such as a draw scratch is on the inside of the shell case, the Laser System will never see it.

With the recent advances in X-ray technology the automated X-ray television system appears to have real promise in the high speed inspection of shell cases for the "SCAMP" project. The X-ray system does not have the disadvantages of other systems of inspection and can gain more information about the condition of the shell cases with the ability of being manual or automatic.

With the information gained by this project as to what equipment is commercially available and what companies have the knowledge to produce such a system is is recommended that more serious consideration be given to the Automated X-ray Television System. It is also recommended now with a better knowledge of the available equipment that as a further project for one of the students at the Intern Training Center, a proto type be built and tested with samples of shell cases to see how reliable the system can be under operating conditions.

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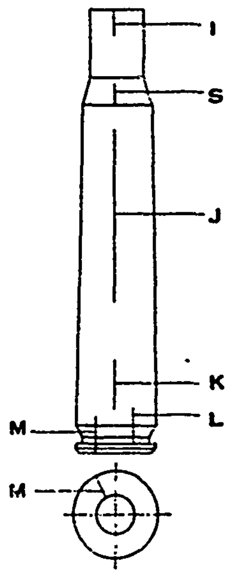
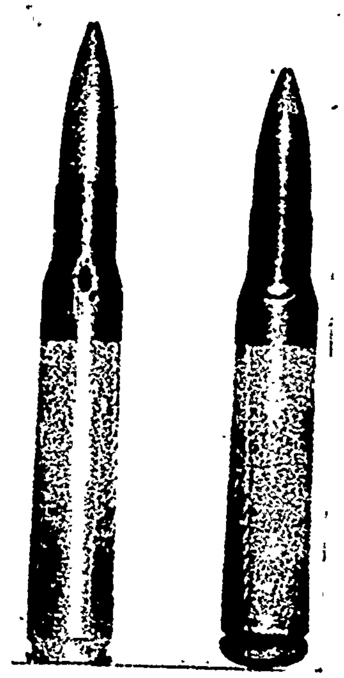
APPENDIX

The following series of pictures were taken from MIL-STD-636 and show some of the different types of defects that can be encountered in the production of small arms ammunition.

A cartridge is to be counted as a defective because of a split case if the cartridge case shows a definite separation of the metal entirely through the case wall.



A cartridge is to be classified either as a "major" or "critical" defective depending on location of split. A split in the (I), (S) or (J) position shall be counted as a "major" defect when no loss of powder occurs; and as a "critical" defect when loss of powder occurs. A split in the (K), (L), or (M) position shall be counted as a "critical" defect.



[— — — Critical — — —]

Perforated Case

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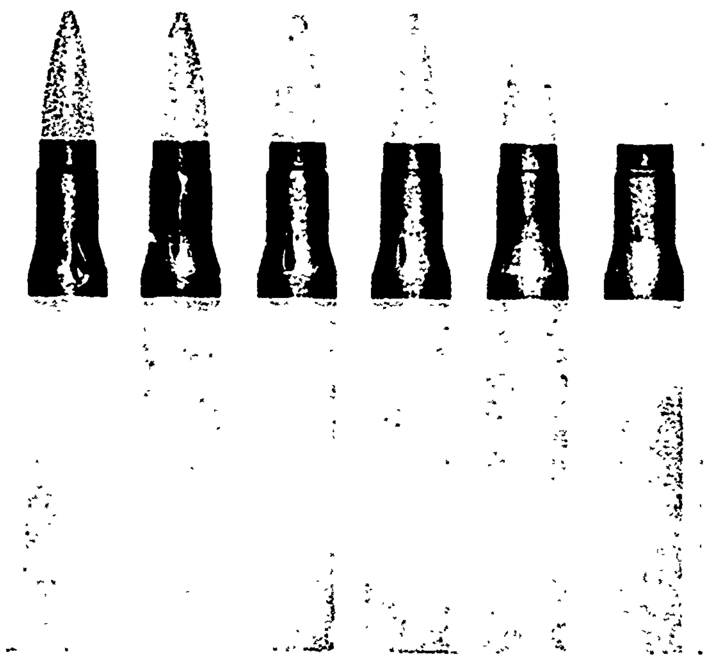
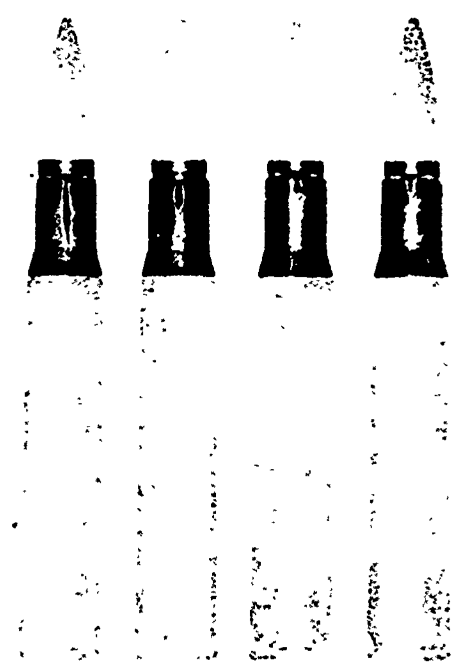


[— — Minor — —] [— — — — — — Permissible — — — — — —]

Fold

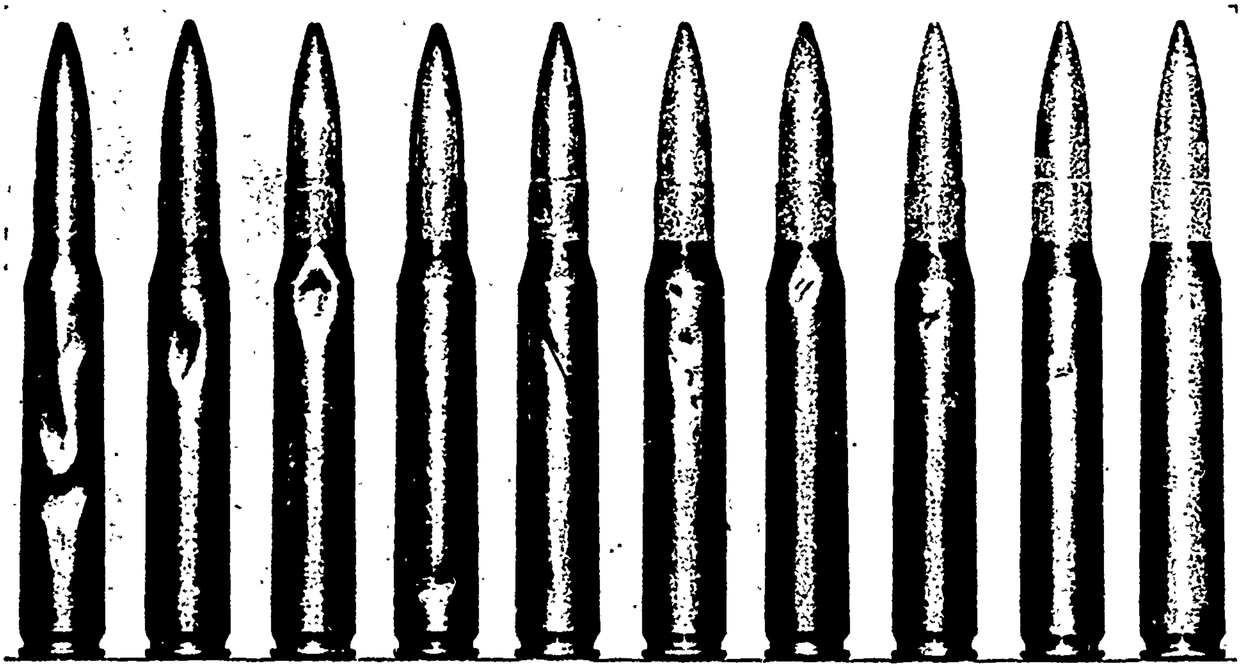
[— — — — Minor — — — —] [Permissible]

Wrinkle



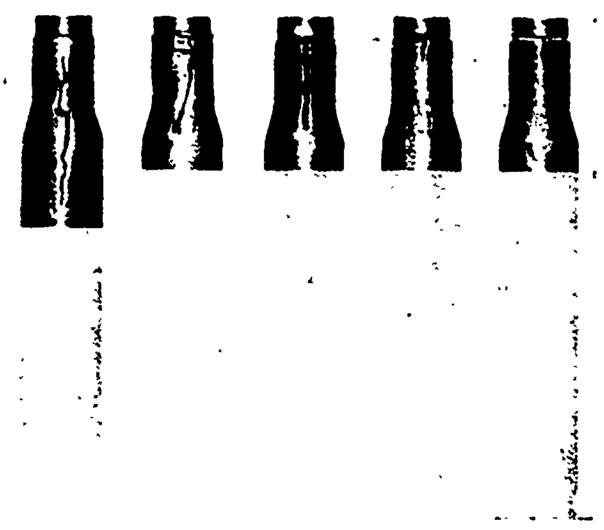
[— — — — Minor — — — —] [Permissible]

Buckle



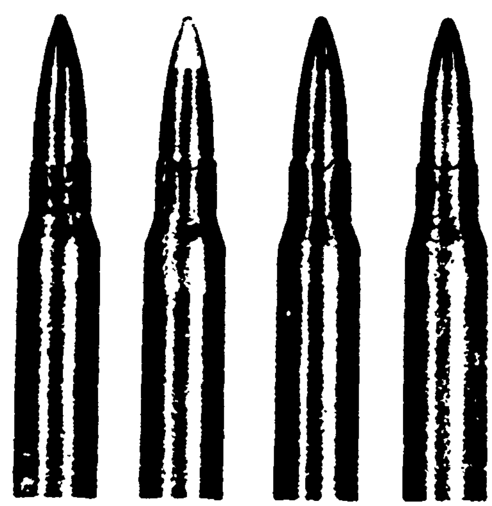
[— — — — — — — Major — — — — — — —] [— — — — — — — Minor — — — — — — —] [— — Permissible — —]

Dent (case)



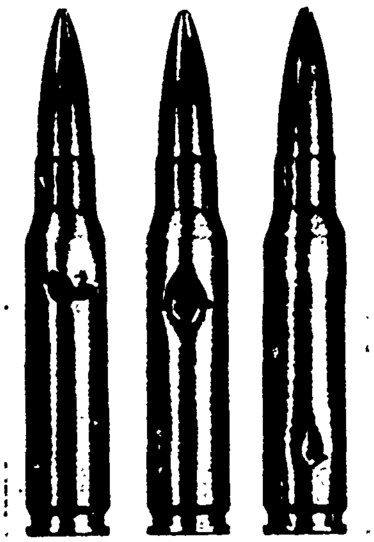
[— — — — — — — — Major — — — — — — — —]

Split Case



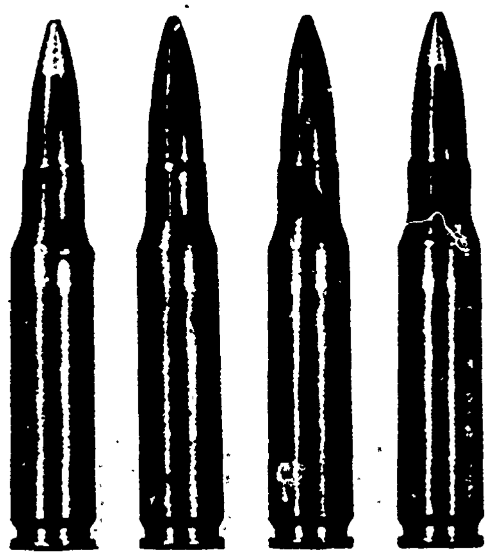
[— — — — — Minor — — — — —] [Permissible]

Defective Mouth



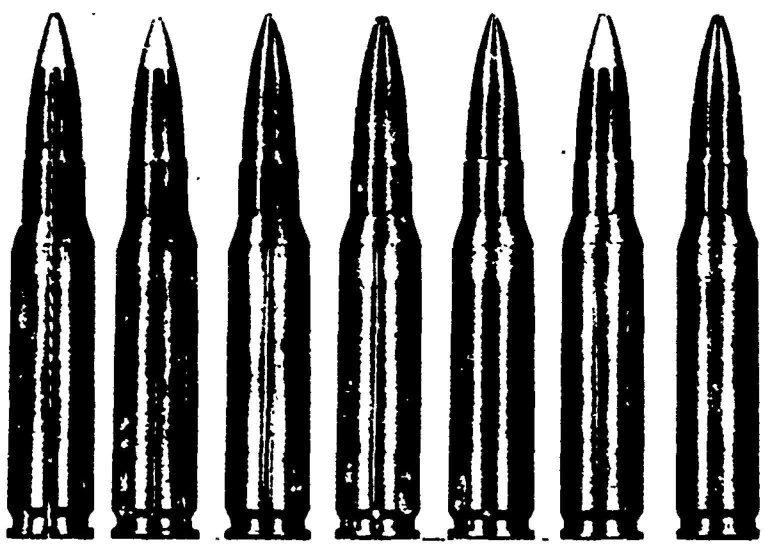
[— — — — Critical — — — —]

Perforated Case



[— — — — — — — — Permissible — — — — — — — —]

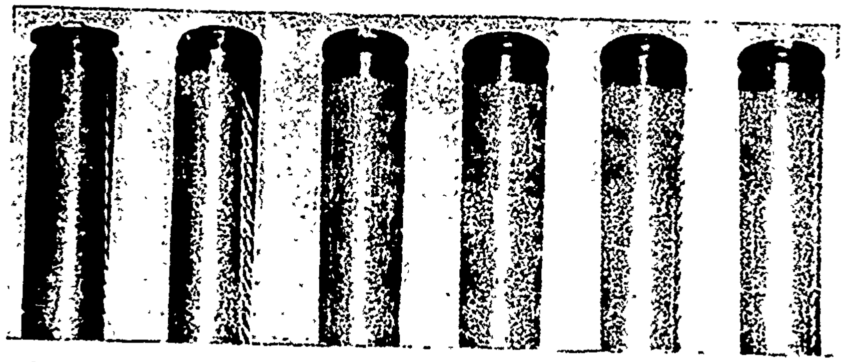
Bulge



[— — Major — —] [— — Minor — —] [— — — — Permissible — — — —]

Draw Scratch

The seriousness of a draw scratch is to be determined by the depth, location and shape of the scratch. Draw scratches which cannot be detected by the finger nail are permissible. Draw scratches which CAN be detected by the finger nail but do not extend into the neck section are to be counted as minor draw scratches. Draw scratches which CAN be detected by the finger nail and extend into the neck section are to be counted as major draw scratches.

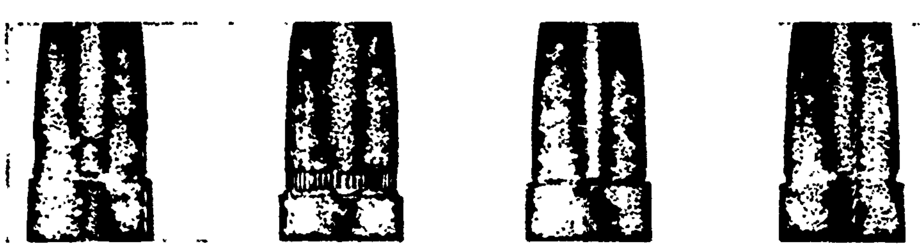


[— — — — — — — — — Minor — — — — — — — — —] [— — Permissible — —]

Defective Head

[— — — — — — — — Minor — — — — — — — —] [— — Permissible — —]

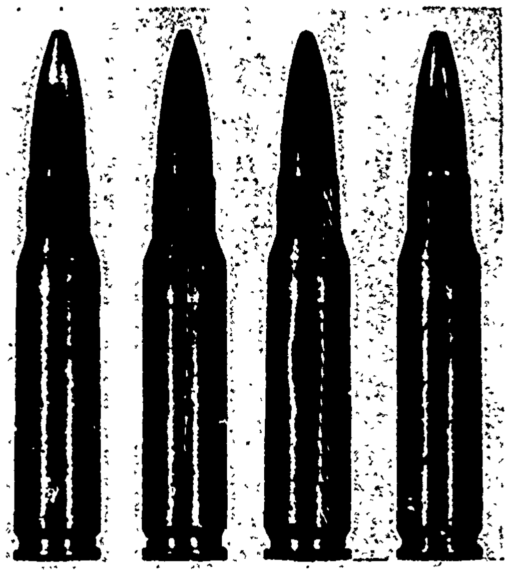
Defective Head



[— — — — — — — — — — — — — — — Major — — — — — — — — — — — — — — —]

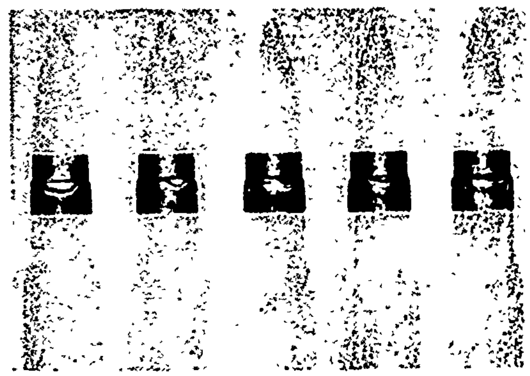
Case Mouth not Crimped in Cannelure (Twice normal size)

A cartridge is also to be counted as a defective because of case mouth not crimped in cannelure if the crimp does not extend around the entire circumference of the case mouth.



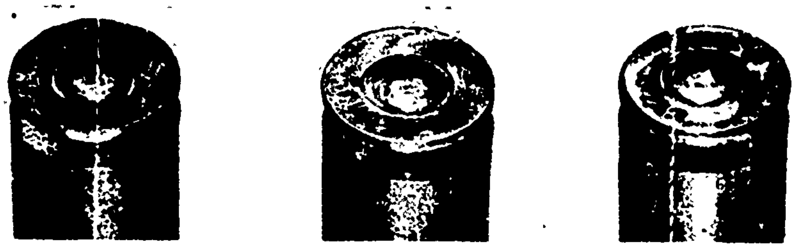
[— — — Minor — — —] [— — Permissible — —]

Scratch (case)



[— — Minor — —] [— — — Permissible — — —]

Defective Mouth



[— — — — — — — Major — — — — — — — —] [— Permissible —]

No Chamfer on Head (rim) (Twice normal size, Inclined view)

[— — — — — — — Major — — — — — — — —] [— Permissible —]

No Chamfer on Head (rim)
(Twice normal size)